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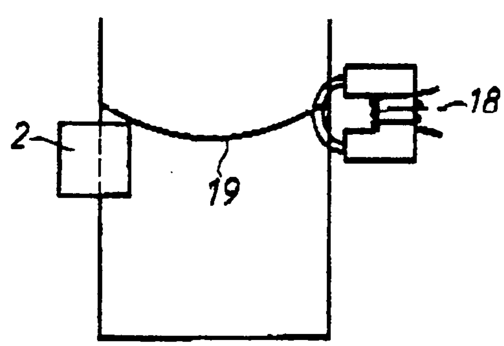
(54) Method of reducing lining wear in a ladle containing a melt.

(57) A method to reduce lining wear in a ladle containing a steel melt, which is heated by at least one electric arc and rotated by an electromagnetic stirrer in a horizontal direction such that a parabolic surface forms on the melt and the slag present in the melt is forced to accumulate towards the centre, thus protecting the ladle lining against the attack of slag and partially against arc radiation. The arc, in addition to heating the charge, also melts the slag. A disturbing device, such as a ceramic pole, a ceramic stone, for example a brick projecting into the melt, a ceramic wing immersing into or arranged below the bath surface, or an electromagnetic brake (18), is arranged such, preferably by immersion into the interface between melt and slag, as to bring about an efficient mixing of steel melt and slag.

Fig. 7a



EP 0 286 934 A1

Method of reducing lining wear in a ladle containing a melt

The invention relates to a method of reducing lining wear in a ladle containing a melt according to the pre-characterizing part of Claim 1.

A method and a device for increasing the efficiency of reactions between slag and melt in a bath of molten metal, for example in connection with sulphur removal from steel melts, is previously known from EP-A-86117529.7 with this method, stirring of the melt takes place by means of at least one inductive stirrer, the stirring being performed in such a way that the force vector of the stirring is composed of a horizontal and a vertical component.

One problem in connection with arc heating of steel melts in a ladle is the wear of the lining which is caused, inter alia, by radiation from the arc. Another problem is the mixing of steel melt and slag, for example for sulphur removal. The homogenization of the melt may also present problems.

The invention aims to provide a solution to the above problems and to improve the method described in the above-men tioned patent application with respect to lining protection and improved intensity of mixing steel and slag to increase metallurgical efficiency such as sulphur removal from a steel melt.

To achieve this aim the invention suggests a method according to the introductory part of Claim 1, which is characterized by the features of the characterizing part of Claim 1.

Further developments of the invention are characterized by the features of the additional claims.

The stirring, which is suitably obtained from a horizontally acting electromagnetic stirrer fed with multi-phase current, is carried out such that the melt and the slag are brought to rotate horizontally by appropriately arranging the stirrer in relation to a ladle filled with steel melt. This results in great flexibility with respect to the flow pattern. During horizontal rotation of the melt, the slag accumulates in the central area of the surface of the melt below the arcs and will thus easily be melted down. In addition, by the action of the disturbing device a turbulence is obtained in the melt, which has metallurgical advantages such as direct sulphur removal and increased homogenization.

By the method according to the invention, contact between slag and lining can be avoided and thus the wear of the lining be reduced. The parabolic surface protects the ladle wall from radiation emanating from the arcs.

In one embodiment of the invention, the melt is stirred not only by a horizontally acting electromagnetic stirrer but additionally by a vertically acting stirrer, separated from and suitably diametrically located in relation to the first-mentioned stirrer. The latter stirrer is provided to increase the homogenization of the melt.

By increasing the parabola height by increased horizontal rotation, the current as well as electrode consumption can be reduced.

The invention will now be described in greater detail with reference to the accompanying drawings showing - by way of example - in

Figures 1a and 1b the use of two stirrers,

Figures 2a and 2b the use of a ceramic pole as a disturbing device,

Figures 3a and 3b the use of a ceramic stone as a disturbing device,

Figures 4a and 4b the use of a ceramic wing as a disturbing device,

Figure 5 an electromagnetically functioning disturbing pole,

Figures 6a and 6b the application of the disturbing pole shown in Figure 5,

Figures 7a and 7b a disturbing device in the form of an electromagnet,

Figure 8 an arrangement with a horizontal stirrer and an electromagnet.

Figure 1a shows a ladle 1 and an electromagnetic stirrer 2, fed with multi-phase current and located at the side of the ladle 1. Figure 1b shows the same arrangement from above. By selecting the direction of the travelling magnetic field, the stirring can take place in either of the directions indicated by the arrows 3 and 4. The stirring causes rotation of the melt, for example a steel melt, which rotation enforces a parabolic shape on the surface 5 of the melt, the slag 6 accumulating in the centre thereof where it is easily melted down by the arc 7 from the arcing electrode or electrodes 8. In this way, substantial protection of the lining of the ladle 1 is obtained. Also, substantial protection is obtained against direct radiation from the arc 7 towards the wall of the ladle 1. Direct contact between slag and lining is also avoided, which considerably increases the life time of the lining. If desired, the arrangement can be supplemented with a vertical stirrer 9, which stirs in the vertical direction and increases the homogenization of the melt and the homogenization of the temperature in the melt. The slag accumulated at the centre will thus be readily melted down. Refining effects, such as sulphur-removal, can be obtained and possibly improved. In this connection also an efficient mixing of steel and slag is obtained.

The ladle 1, is provided with a disturbing device as will be described in the following.

Figures 2a and 2b show the immersion of a disturbing pole or rod 10 of ceramic, or other

refractory material, into the melt. This disturbs the motion of the melt caused by the horizontally acting stirrer 11 and leads to a more efficient mixing of steel and slag, which, among other things, increases the intensity of the sulphur removal. Figure 2b shows the stirring direction and the ceramic pole 10, which is arranged eccentrically in relation to the vertical axis of the ladle and at the interface between steel and slag.

Figures 3a and 3b show a device similar to that shown in Figures 2a, 2b, but with the disturbing device in the form of a ceramic stone, such as a brick 12, projecting into the melt, suitably below the surface of the melt at the ladle wall. In the same way as in the case of the above-described pole 10, a disturbance of the stirring and hence an intensified mixing of slag and steel are obtained. The ceramic stone 12 is to have such dimensions that it projects from the inner wall of the ladle into the melt at or immediately below the surface of the melt (see Figure 3a).

An alternative embodiment of a disturbing device is shown in Figures 4a and 4b, in which a ceramic wing 12 is immersed into the melt or arranged below the melt surface. Also in this case, intensified mixing of slag and steel melt is obtained.

Figure 5 shows an electromagnetic disturbing device, consisting of surrounding an iron core 15 surrounded by a coil 14. The iron core 15 projects down towards the melt and magnetically presses down the melt when the coil 14 is supplied with current (see the melt surface 16). The application is also clear from Figures 6a and 6b, which shows the parabolic surface 17 caused by the stirrer which is not being shown. It also shows the iron core 15 and the coil 14 the magnetic field of which presses down the melt to an additional extent for the purpose of intensifying the rate of mixing. The electromagnetic disturbing device which locally decelerates the melt may, for example, create a stationary alternating field, a travelling field (suitably with a frequency different from that of the stirrer 2), and/or a continuous field. The position of the disturbing pole is also shown in Figure 6b, which is a view from above on the ladle in Figure 6a.

Figures 7a and 7b show an electromagnet 18 with its coil being supplied with direct current and acting at a location in the ladle substantially diametrically opposite to that of the stirrer 2, which acts in the horizontal direction in order to achieve a parabolic melt surface 19. The d.c. supplied magnet 18 decelerates the melt locally, thus causing increased stirring (see also the cross section in Figure 7b).

In prior art ladles with normal stirring, the removal of sulphur from steel proceeds relatively slowly. With the method according to the invention, among other things according to Figure 8, the rate of mixing of slag and melt, and therefore the sulphur removal, can be improved. A horizontally acting stirrer 21, acting in the circumferential direction, is placed at the ladle 20. Diametrically opposite thereto, or somewhat angularly displaced in relation thereto, an electromagnetic coil 22 is arranged which generates a magnetic field at the surface of the melt, which acts as an electromagnetic brake. At the location of the coil 22, the surface dividing the slag and the melt is disturbed, thus obtaining a vigorous mixing. Figure 8 clearly shows the location of the coil 22 in relation to the slag 23, and the mixing starts at 24.

The method according to the above can be varied in many ways within the scope of the following claims.

Claims

1. Method of reducing lining wear in a ladle containing a melt, preferably a steel melt, which is heated by at least one electric arc (7) and rotated by an electromagnetic stirrer (2) in a horizontal direction such that a parabolic surface forms on the melt, **characterized** in that the force of the horizontally travelling magnetic field is chosen such that the slag (6) present in the melt accumulates in the central area, thus protecting the ladle lining against the attack of slag and partially against arc radiation, that the arc or arcs (7), in addition to heating the charge, also melts/melt the slag (6), and that a disturbing device (10,12), such as a ceramic pole (10), a ceramic stone (12), for example a brick projecting into the melt, a ceramic wing (13) immersing into or arranged below the bath surface, or an electromagnetic brake, is arranged such, preferably by immersion into the interface between melt and slag, as to bring about an efficient mixing of melt and slag, for example for intensifying sulphur removal from a steel melt.

2. Method according to Claim 1, **characterized** in that the parabola height is increased by increased horizontal rotation, whereby the current as well as the electrode consumption can be reduced.

3. Method according to Claim 1 or 2, **characterized** in that an electromagnetic disturbing pole (14,15) is lowered towards the surface of the melt, said disturbing pole magnetically pressing down the melt surface.

4. Method according to Claim 1, **characterized** in that a magnet (18), supplied with direct current, or electromagnetic means is/are applied at the melt surface of the ladle, said magnet or electromagnetic means decelerating the melt, by pro-

ducing for example a stationary alternating field or a travelling field, separated from that of the ordinary stirring (2).

5. Method according to any of the preceding claims, **charaterized** in that the melt is stirred by a horizontally acting, electromagnetic stirrer (2) and by a vertically acting stirrer (9), separated from and suitably diametrically located in relation to the first-mentioned stirrer.

6. Method according to Claim 3, **characterized** in that the melt is stirred by a horizontally acting, electromagnetic stirrer (2) and that the stirring thus obtained is disturbed by an additional magnetic field generated by a coil (18), substantially diametrically located in relation to the stirrer (2), said coil (18) being supplied, for example with direct current or single-phase alternating current such as to act as an electromagnetic brake.

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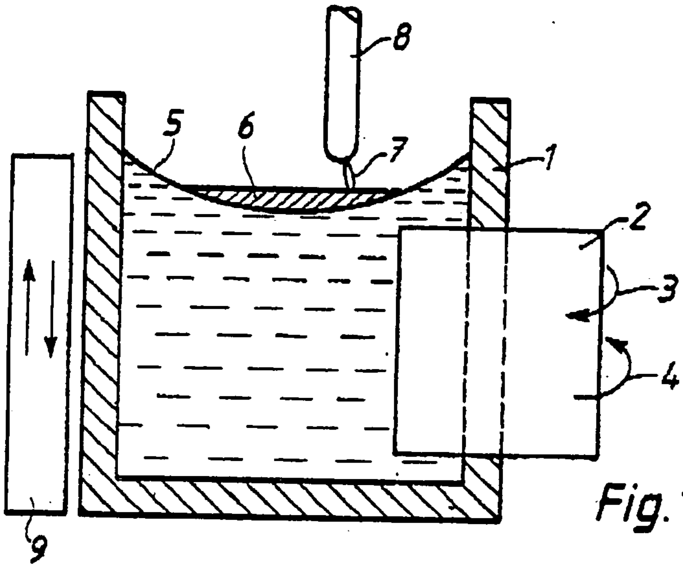

Fig. 1a

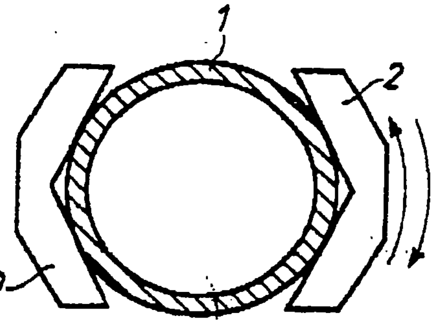

Fig. 1b

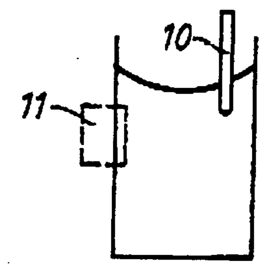

Fig. 2a

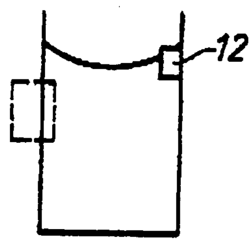

Fig. 3a

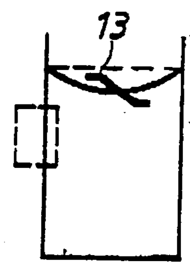

Fig. 4a

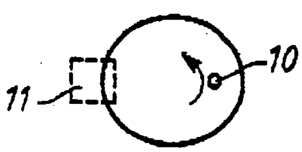

Fig. 2b

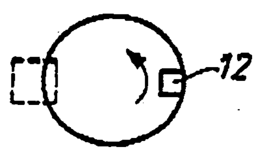

Fig. 3b

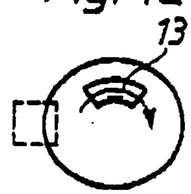

Fig. 4c

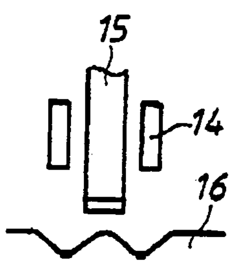

Fig. 5

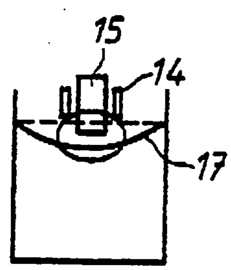

Fig. 6a

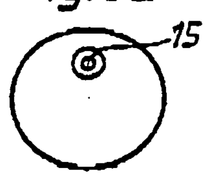

Fig. 6b

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Fig.7a

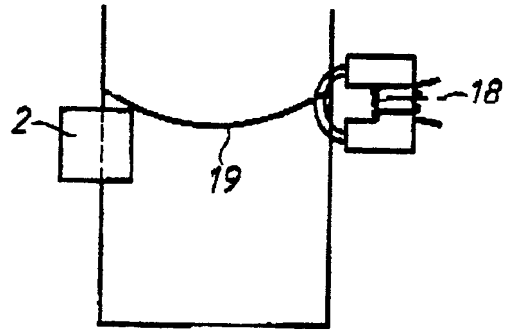


Fig.7b

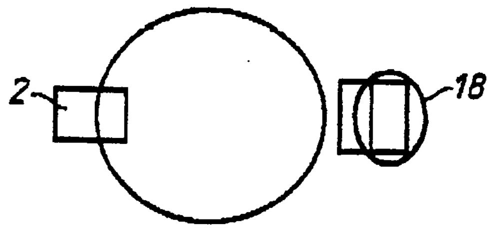
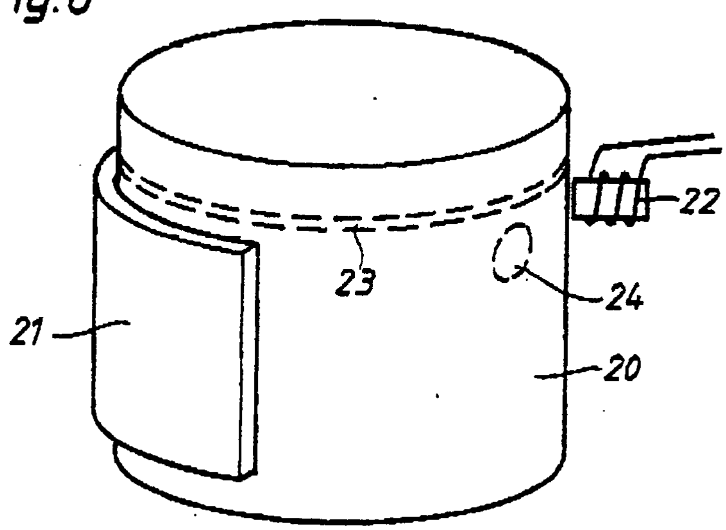


Fig.8



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EUROPEAN SEARCH REPORT

Application number

EP 88 105362.3

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	SE-B- 447 846 (ASEA AB) *See eg page 2, lines 29-32* ---	1, 4-6	F 27 D 23/04 C 21 C 5/52
Y	Patent Abstract of Japan vol. 9, No 237 (C-305), abstract of JP 60-96735, publ. 30 May 1985 ---	1, 2 4-6	
E	EP-A2- 228 024 (ASEA AB) ---	1, 3	
A	US-A- 2 139 853 (W ROHN) ---	1, 2	
A	DE-A- 726 975 (STALTURBINE) ---	1, 4-6	
A	FR-A- 764 178 (ELECTRO-THERMIQUES)		

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

F 27 D
C 21 C
C 22 B
H 05 B
B 22 D
F 27 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
STOCKHOLM	07-07-1988	HULTHEN M.

CATEGORY OF CITED DOCUMENTS

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